

EXHIBIT 1

Multi-Perspective Panoramas of City Blocks

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with

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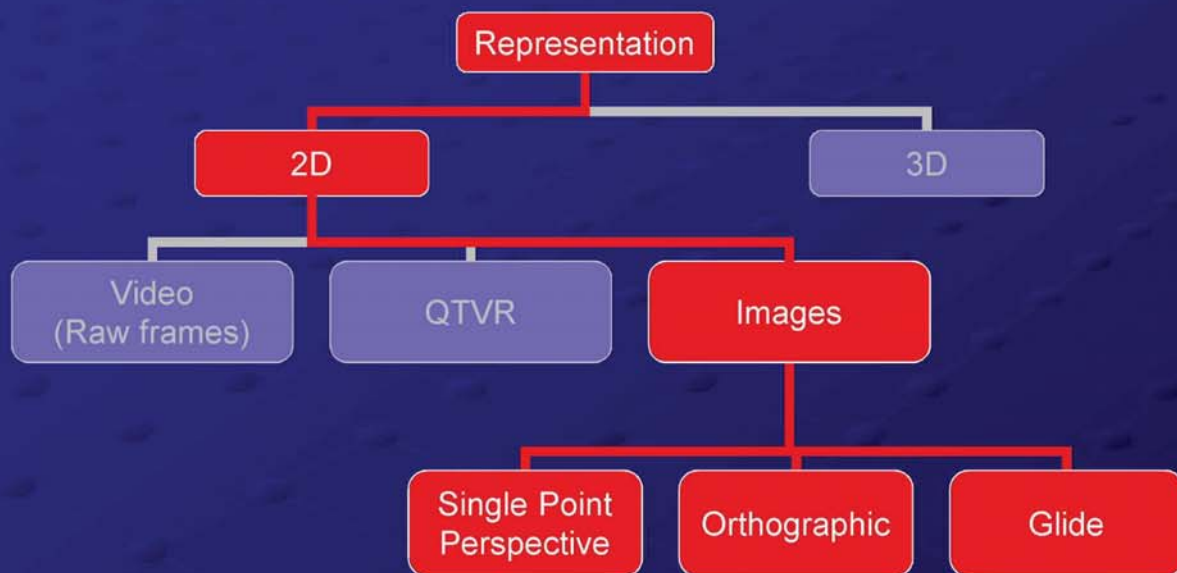
Motivation

- Goal:
 - To obtain a useful representation for viewing an entire commercial city block.
- Uses
 - Web-based map finders – Get a picture of the place you want to go!
 - “A picture is worth a thousand words” – Chinese proverb
 - Associate URLs with an image of the specific store
 - Virtual tours



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Taxonomy of Representations



We choose to focus on image-based representations

- Standard on web
- Relatively low-bandwidth

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Geometric Issues

- Two extreme representations for presenting the images
 - Single-point perspective projection
 - Our eyes are more accustomed to it
 - Orthographic projection

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Geometric Issues: Perspective

- Extreme 1: Create a single-perspective image of the entire block



Taken from an EE368A Project by Laurent Meunier and Moritz Borgmann
http://ise0.stanford.edu/class/ee368a_proj00/project13/

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Geometric Issues: Perspective

● Problems:

- Doesn't give the impression that the viewer is standing right in front of the store, except at the center.
- Using vision techniques to create the image is hard because of depth variation (parallax)
- Using special fish-eye lenses, high distortion towards edges

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Geometric Issues: Orthographic

- Extreme 2: Create an orthographic image of the entire block
- Problems:
 - Even harder to generate – possibly with an array of video cameras
 - Doesn't look good anyways

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Geometric Issues: Glide

- Our method: 'Glide' Projection of block
 - Aka "Cross-slits" and multi-perspective projection
 - Orthographic horizontally, perspective vertically
- Rather than having a single vanishing point (perspective), the vanishing point can "glide"
- Advantages:
 - Conveys both the immediate presence of the building vertically and allows viewing entire block equally

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Approach

- Take a panning video of street block
- Extract “a” column of pixels from each frame.
 - If the center column is taken, creates a head-on glide projection horizontally
 - If the an offset column is taken, creates a left or right glide projection horizontally



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Getting the video

- Used Castro Street, Mountain View
- Drove at 1-2 mph
- Before sunrise on Sunday mornings
 - Few people
 - Low traffic
 - No sun reflections
- Used prosumer Sony camcorder
 - 720x480@30 fps interlaced
 - Separated fields to achieve 720x240@60 fps video
 - Autoexposure off



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Some of the best results...



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Some of the best results...



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Some of the best results...



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Some of the best results...



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Logistics

- There are ~2.4 million miles of paved road in the US
- We estimate that about ~1% are commercial
- With a high speed camera (~250 fps), we can capture driving at about 10 mph
- It will take approximately 100 days worth of driving time to capture the entire commercial US.
 - Spread among 20 vehicles and allowing 6 hours of capture time per day, it would require approximately 20 days of acquisition.

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